PB-239 644

LAKE ANDRUSIA, BELTRAMI COUNTY, MINNESOTA

Pacific Northwest Environmental Research Laboratory

Prepared for:

National Environmental Research Center
Minnesota National Guard
Minnesota Pollution Control Agency

November 1974

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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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REPORT
ON
LAKE ANDRUSIA
BELTRAMI COUNTY
MINNESOTA

EPA REGION V

WORKING PAPER No. 81

WITH THE COOPERATION OF THE

MINNESOTA POLLUTION CONTROL AGENCY

AND THE

MINNESOTA NATIONAL GUARD

NOVEMBER, 1974

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F O R E W O R D

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Minnesota Pollution Control Agency for professional involvement and to the Minnesota National Guard for conducting the tributary sampling phase of the Survey.

Grant J. Merritt, Director of the Minnesota Pollution Control Agency, John F. McGuire, Chief, and Joel G. Schilling, Biologist, of the Section of Surface and Groundwater, Division of Water Quality, provided invaluable lake documentation and counsel during the course of the Survey; and the staff of the Section of Municipal Works, Division of Water Quality, were most helpful in identifying point sources and soliciting municipal participation in the Survey.

Major General Chester J. Moeglein, the Adjutant General of Minnesota, and Project Officer Major Adrian Beltrand, who directed the volunteer efforts of the Minnesota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

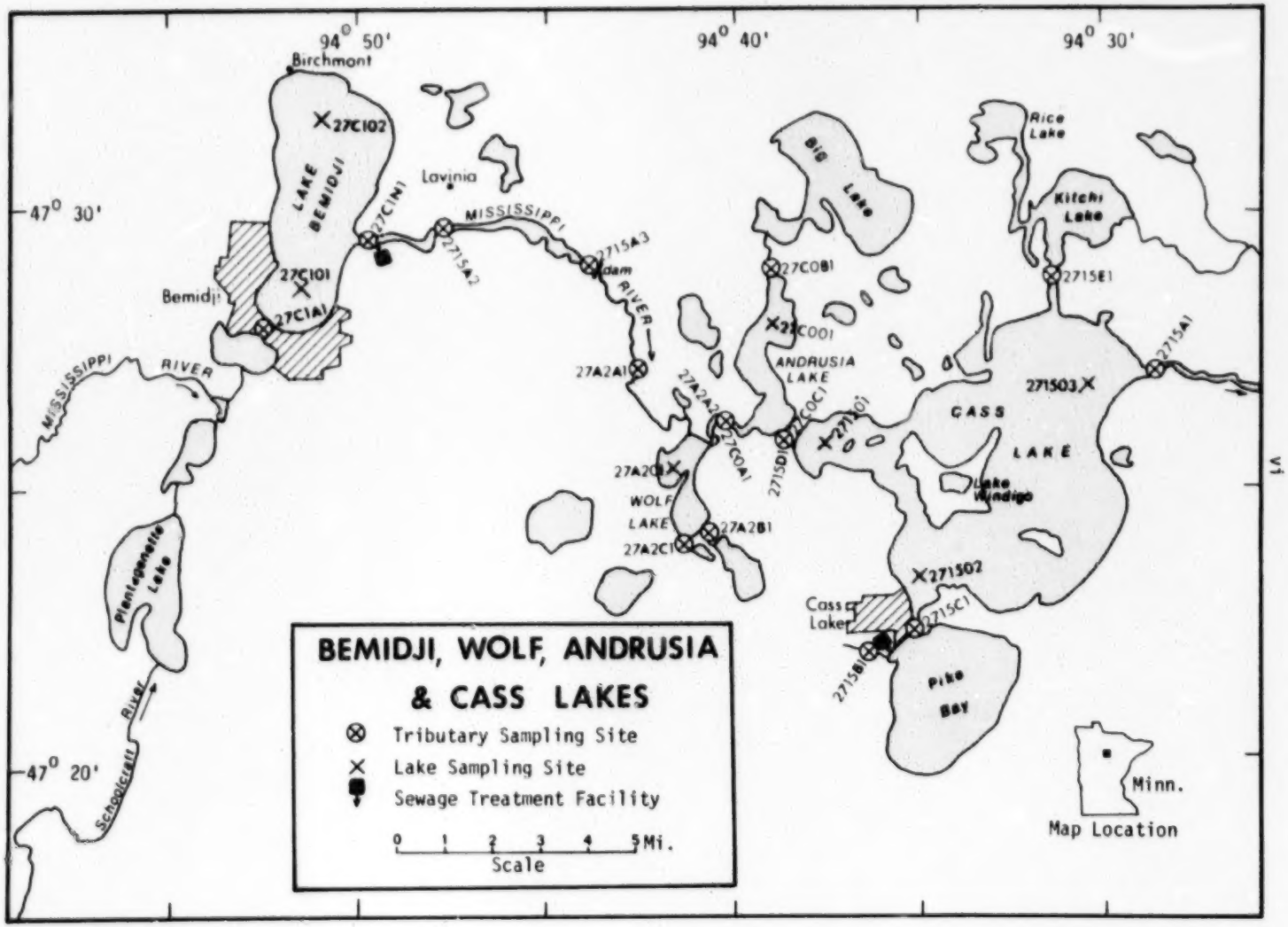
NATIONAL EUTROPHICATION SURVEY

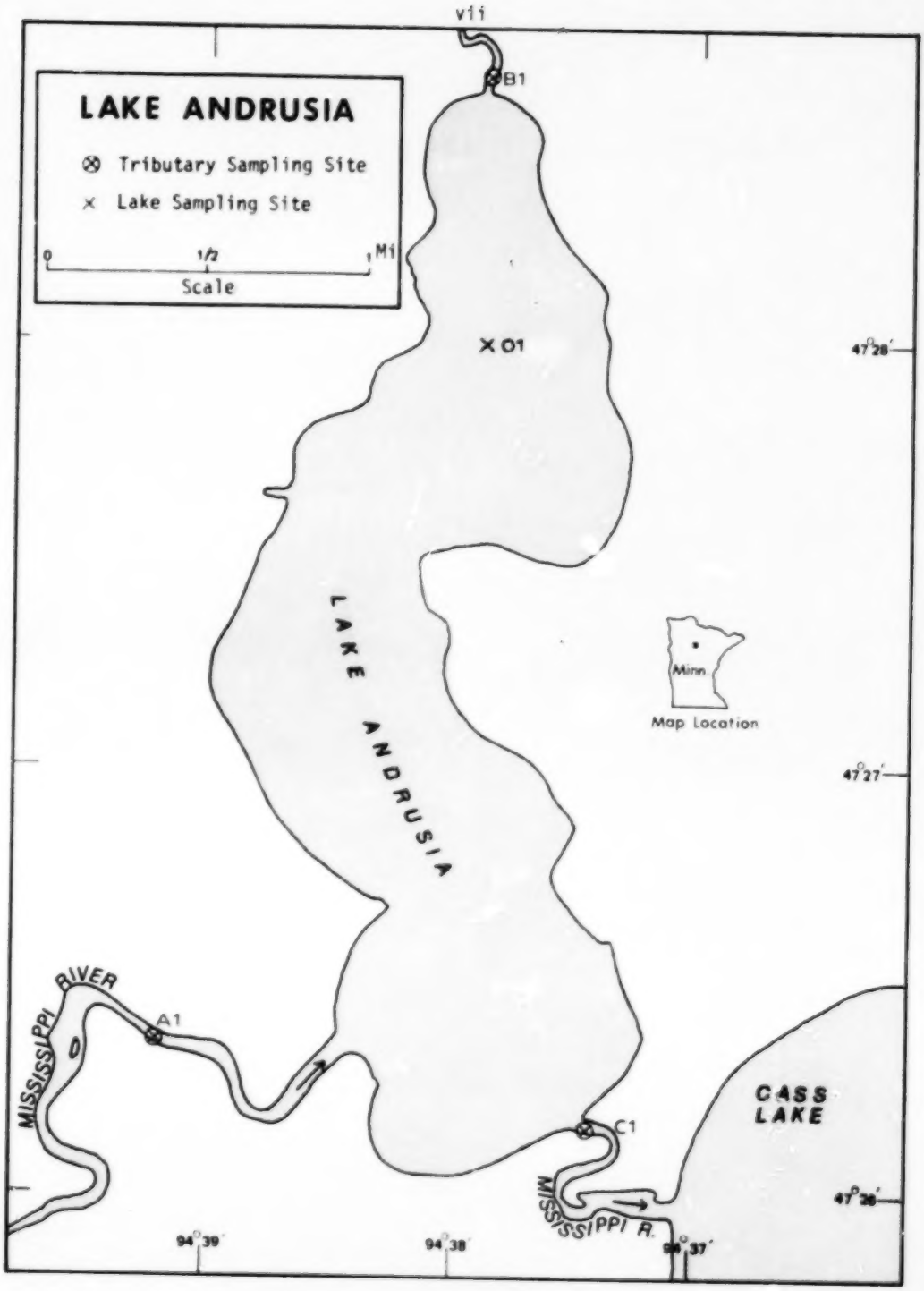
STUDY LAKES

STATE OF MINNESOTA

LAKE NAME	COUNTY
Albert Lea	Freeborn
Andrusia	Beltrami
Badger	Polk
Bartlett	Koochiching
Bear	Freeborn
Bemidji	Beltrami
Big	Stearns
Big Stone	Big Stone, MN; Roberts, Grant, SD
Birch	Cass
Blackduck	Beltrami
Blackhoof	Crow Wing
Budd	Martin
Buffalo	Wright
Calhoun	Hennepin
Carlos	Douglas
Carrigan	Wright
Cass	Beltrami, Cass
Clearwater	Wright, Stearns
Cokato	Wright
Cranberry	Crow Wing
Darling	Douglas
Elbow	St. Louis
Embarass	St. Louis
Fall	Lake
Forest	Washington
Green	Kandiyohi
Gull	Cass
Heron	Jackson
Leech	Cass
Le Homme Dieu	Douglas
Lily	Blue Earth
Little	Grant
Lost	St. Louis

LAKE NAME	COUNTY
Madison	Blue Earth
Malmedal	Pope
Mashkenode	St. Louis
McQuade	St. Louis
Minnetonka	Hennepin
Minnewaska	Pope
Mud	Itasca
Nest	Kandiyohi
Pelican	St. Louis
Pepin	Goodhue, Wabasha, MN; Pierce, Pepin, WI
Rabbit	Crow Wing
Sakatah	Le Sueur
Shagawa	St. Louis
Silver	McLeod
Six Mile	St. Louis
Spring	Washington, Dakota
St. Croix	Washington, MN; St. Croix, Pierce, WI
St. Louis Bay	St. Louis, MN; Douglas, WI
Superior Bay	St. Louis, MN; Douglas, WI
Swan	Itasca
Trace	Todd
Trout	Itasca
Wagonga	Kandiyohi
Wallmark	Chisago
White Bear	Washington
Winona	Douglas
Wolf	Beltrami, Hubbard
Woodcock	Kandiyohi
Zumbro	Olmstead, Wabasha


94° 50'
94° 40'
94° 30'
47° 30'
47° 20'
Birchmont
27C102
LAKE BEMIDJI
27C1N1
Lavinia
MISSISSIPPI
27I5A2
27I5A3
Dam
RIVER
27C101
Bemidji
27C1A1
MISSISSIPPI RIVER
27A2A1
27C0B1
27C001
ANDRUSIA LAKE
27A2A2
27C0A1
27I5D1
27C0C1
27I501
271503
CASS
LAKE
Lake Windigo
27A2C1
WOLF LAKE
27A2B1
271502
Cass Lake
27I5C1
27I5B1
Pike Bay
Big Lake
Rice Lake
Kitchi Lake
27I5E1
27I5A1
Pleasant Lake
Schoolcraft River
BEMIDJI, WOLF, ANDRUSIA & CASS LAKES
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0 1 2 3 4 5 Mi.
Scale
Minn.
Map Location


LAKE ANDRUSIA
Tributary Sampling Site
Lake Sampling Site
0
1/2
1 Mi
Scale
B1
O1
47°28'
LAKE ANDRUSIA
Minn.
Map Location
47°27'
MISSISSIPPI RIVER
A1
C1
CASS LAKE
MISSISSIPPI R.
47°26'
94°39'
94°38'
94°37'

LAKE ANDRUSIA

STORET NO. 27C0

I. CONCLUSIONS

A. Trophic Condition:

Survey data and the records of others indicate that Lake Andrusia is eutrophic. Of the 60 Minnesota lakes sampled in the fall when essentially all were well-mixed, 14 had less mean total phosphorus, 9 had less mean dissolved phosphorus, and 9 had less mean inorganic nitrogen. Of the 80 lakes sampled, 46% had less mean chlorophyll a, and 45% had greater Secchi disc transparency. Marked depression of dissolved oxygen with depth was observed in July and September of 1972.

Survey limnologists noted a moderate algal bloom in progress during the October sampling. The records of others indicate rooted aquatic vegetation is prevalent in the shallows of Lake Andrusia (Lang, et al., 1969).

B. Rate-Limiting Nutrient:

A significant loss of inorganic nitrogen occurred in the algal assay sample from the time of collection to the time the assay was begun, and the results are not reliable.

The lake data indicate phosphorus limitation in October.

C. Nutrient Controllability:

1. Point sources--During the sampling year, Lake Andrusia received a total phosphorus load at a rate more than that proposed

by Vollenweider (in press) as dangerous; i.e., a eutrophic rate (see page 13). Of that load, it is estimated that the Bemidji wastewater treatment plant indirectly contributed about 48% (allowing for 12% retention in Wolf Lake; see "Report on Wolf Lake," Working Paper No. 136).

When the phosphorus removal facilities at the Bemidji STP become operational (Schilling, 1974), it is calculated that the total phosphorus load to Lake Andrusia will be reduced by about 44%. This will reduce the loading rate from the existing 36 lbs/acre/yr (4 $g/m^2/yr$) to about 20 lbs/acre/yr or about 2.3 $g/m^2/yr$.

The new loading rate will still be about 1½ times greater than the dangerous or eutrophic rate. However, as with Wolf Lake, the Lake Andrusia inlet is so near the outlet (see map, page vii) it is believed that nutrient short-circuiting occurs; i.e., under most flow conditions, it is probable that much of the incoming water (with nutrients) flows more or less directly to the outlet. Therefore, it is concluded that the degree of phosphorus removal to be instituted at the Bemidji wastewater treatment plant will result in improvement in the trophic condition of Lake Andrusia.

2. Non-point sources (see page 13)--The phosphorus exports in the Lake Andrusia drainage were very similar to those of the drainages of the other lakes in this upper Mississippi River chain of lakes. The relatively low exports probably result from the near-headwaters location of the lakes as well as land-use practices in this largely-forested area of Minnesota.

In all, it is estimated that non-point sources contributed about 52% of the total phosphorus load reaching Lake Andrusia during the sampling year.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry†:

1. Surface area: 1,510 acres.
2. Mean depth: 26 feet.
3. Maximum depth: 60 feet.
4. Volume: 39,260 acre/feet.
5. Mean hydraulic retention time: 47 days.

B. Tributary and Outlet:
(See Appendix A for flow data)

1. Tributaries -

Name	Drainage area††	Mean flow††
Mississippi River†††	684.0 mi^2	404.5 cfs
Big Lake outlet	30.6 mi^2	14.6 cfs
Minor tributaries & immediate drainage* -	15.0 mi^2	2.2 cfs
Totals	729.6 mi^2	421.3 cfs

2. Outlet -

Mississippi River	732.0 mi^2**	421.3 cfs

C. Precipitation***:

1. Year of sampling: 26.7 inches.
2. Mean annual: 23.8 inches.

† DNR lake survey map (1941); mean depth by random-dot method.
†† Drainage areas are accurate within ±5%; mean daily flows are accurate within ±10%; and ungaged flows are accurate within ±10 to 25% for drainage areas greater than 10 mi^2.
††† Area adjusted to equal Wolf Lake outlet area.
* Adjusted so sum of subdrainage areas and flows equal outlet.
** Includes area of lake.
*** See Working Paper No. 1, "Survey Methods".

III. LAKE WATER QUALITY SUMMARY

Lake Andrusia, one of a chain of upper Mississippi River lakes (see map, page vi), was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at one station on the lake (see map, page vii). During each visit a single depth-integrated (15 feet to surface) sample was collected for phytoplankton identification and enumeration; and during the last visit, a single five-gallon depth-integrated sample was taken for algal assays. Also each time, a depth-integrated sample was collected for chlorophyll *a* analysis. The maximum depth sampled was 31 feet.

The results obtained are presented in full in Appendix B, and the data for the fall sampling period, when the lake was essentially well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix B.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (10/21/72)		
Temperature (Cent.)	6.9	6.9	6.9	6.9
Dissolved oxygen (mg/l)	10.1	11.2	11.4	11.9
Conductivity (μmhos)	240	242	242	242
pH (units)	8.2	8.2	8.2	8.3
Alkalinity (mg/l)	136	137	137	139
Total P (mg/l)	0.024	0.031	0.031	0.039
Dissolved P (mg/l)	0.010	0.014	0.013	0.018
NO_2 + NO_3 (mg/l)	0.040	0.042	0.040	0.050
Ammonia (mg/l)	0.060	0.066	0.060	0.080
		ALL VALUES		
Secchi disc (inches)	42	54	60	60

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
07/11/72	1. Anabaena	768
	2. Flagellates	572
	3. Microcystis	557
	4. Dinobryon	497
	5. Oscillatoria	361
	Other genera	438
	Total	3,193
09/08/72	1. Microcystis	1,398
	2. Anabaena	470
	3. Aphanocapsa	217
	4. Flagellates	205
	5. Lyngbya	169
	Other genera	408
	Total	2,867
10/21/72	1. Melosira	2,259
	2. Anabaena	452
	3. Flagellates	452
	4. Scenedesmus	286
	5. Dinobryon	271
	Other genera	1,174
	Total	4,894

2. Chlorophyll *a* -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
07/11/72	01	11.0
09/08/72	01	10.5
10/21/72	01	17.4

C. Limiting Nutrient Study:

Between the time the algal assay sample was collected and and the assay was begun, a 33% loss of inorganic nitrogen occurred. Therefore, the assay results are not reliable.

The lake data indicate phosphorus limitation in July (N/P = 17/1) and September (N/P = 40/1) but nitrogen limitation in October (N/P = 8/1).

IV. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, from October, 1972, through September, 1973, the Minnesota National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vii), except for the high runoff month of April, when two samples were collected, and the colder months when samples were omitted because of ice cover.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Minnesota District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by using the mean of the nutrient loads, in lbs/mi^2/year, in tributaries of nearby Leech Lake at stations C-1, D-1, F-1, G-1, H-1, and J-1 and multiplying the means by the ZZ area in mi^2.

There are no known point sources impacting Lake Andrusia directly. The Bemidji wastewater treatment plant discharges to the Mississippi River some distance upstream and thence to Wolf Lake. During the sampling year, Wolf Lake retained 12% of the total phosphorus load and none of the nitrogen load. Therefore, in the following loading tables, the nutrient loads

* See Working Paper No. 1.

attributed to the indirect point source (Bemidji STP) were estimated on the basis of the Wolf Lake retention. The loads attributed to the Lake Andrusia inlet at station COA1 are those measured minus the indirect Bemidji STP loads.

A. Waste Sources:

1. Known municipal (indirect)* -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receiving Water
Bemidji	11,400	trickling filter	0.942	Mississippi River

2. Known industrial - None

* See "Report on Wolf Lake", Working Paper No. 136.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Mississippi River	26,630	49.2
Big Lake outlet	600	1.1
b. Minor tributaries & immediate drainage (non-point load) -	420	0.8
c. Known municipal -		
Bemidji (indirect)	26,160	48.3
d. Septic tanks* -	80	0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	240	0.5
Total	54,130	100.0

2. Outputs -

Lake outlet - Mississippi River 34,280

3. Net annual P accumulation - 19,850 pounds

* Estimated 77 dwellings and 5 resorts on shoreline; see Working Paper No. 1.
** See Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	lbs N/ yr	% of total
a. Tributaries (non-point load) -		
Mississippi River	628,370	78.9
Big Lake outlet	26,870	3.4
b. Minor tributaries & immediate drainage (non-point load) -	18,770	2.4
c. Known municipal -		
Bemidji (indirect)	105,010	13.2
d. Septic tanks* -	2,980	0.4
e. Known industrial - None	-	-
f. Direct precipitation** -	14,550	1.8
Total	796,550	100.0

2. Outputs -

Lake outlet - Mississippi River 703,420

3. Net annual N accumulation - 93,130 pounds

* Estimated 77 dwellings and 5 resorts on shoreline; see Working Paper No. 1.
** See Working Paper No. 1.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	lbs P/mi^2/yr	lbs N/mi^2/yr
Mississippi River	39	919
Big Lake outlet	20	878

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (in press). Essentially, his "dangerous" rate is the rate at which the receiving waters would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

Units	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
lbs/acre/yr	35.8	13.1	527.5	61.7
grams/m^2/yr	4.02	1.47	59.1	6.9

Vollenweider loading rates for phosphorus (g/m^2/yr) based on mean depth and mean hydraulic retention time of Lake Andrusia:

"Dangerous" (eutrophic rate)	1.50
"Permissible" (oligotrophic rate)	0.75

V. LITERATURE REVIEWED

Anonymous, 1973. Wastewater disposal facilities inventory. MPCA, Minneapolis.

Hoekstra, Donald J., 1968. Nitrogen and phosphorus analysis of six Mississippi headwaters lakes. MS, N.S.F. Limnology Inst., Bemidji St. Coll., Bemidji.

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Schilling, Joel, 1974. Personal communication (lake map; treatment requirements at Bemidji). MPCA, Minneapolis.

Vollenweider, Richard A., (in press). Input-output models. Schweiz. A. Hydrol.

VII. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 27C0 ANDROSIA LAKE

TOTAL DRAINAGE AREA OF LAKE 732.00

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
27C0A1	693.00	268.37	192.62	233.44	933.90	958.23	715.02	380.37	218.98	286.01	268.49	214.02	199.43	404.32
27C0B1	30.60	3.74	2.47	5.38	36.30	39.40	28.90	15.20	8.23	14.00	8.72	5.91	6.06	14.60
27C0C1	732.00	281.00	204.00	248.00	837.00	1054.00	748.00	417.00	240.00	313.00	295.00	181.00	212.00	421.25
27C0Z7	7.76	1.02	0.67	1.60	4.35	8.87	7.46	3.47	1.58	4.84	1.73	1.07	1.46	3.50

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 732.00
SUM OF SUB-DRAINAGE AREAS = 731.36

TOTAL FLOW IN = 5065.38
TOTAL FLOW OUT = 5048.00

NOTE *** TRIB C0C1=1501

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
27C0A1	10	72	256.00	14	338.00				
	11	72	210.00	5	210.00				
	12	72	311.00	10	302.00				
	1	73	243.00	20	248.00				
	2	73	214.00	14	214.00				
	3	73	662.00	17	1985.00				
	4	73	243.00	1	258.00	14	224.00		
	5	73	224.00	19	207.00				
	6	73	214.00						
	7	73	155.00	8	165.00				
	8	73	205.00	11	205.00				
	9	73	383.00	16	351.00				
27C0A1	10	72	7.00	14	11.00				
	11	72	5.58	5	5.60				
	12	72	8.11	10	8.80				
	1	73	4.11	20	3.60				
	2	73	2.56	14	2.60				
	3	73	16.30	17	44.00				
	4	73	12.60	1	13.00	14	12.00		
	5	73	12.30	19	11.00				
	6	73	10.20						
	7	73	7.57	8	9.74				
	8	73	10.80	11	10.80				
	9	73	11.70	16	13.60				

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 27C0 ANDRUSIA LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
27C0C1	10	72	13.40	14	14.00				
	11	72	9.33	5	9.40				
	12	72	12.30	10	12.00				
	1	73	247.00	20	250.00				
	2	73	218.20	14	218.00				
	3	73	672.00	17	2020.00				
	4	73	279.70	1	286.00	14	248.00		
	5	73	264.00	19	240.00				
	6	73	230.00						
	7	73	205.00	8	142.00				
	8	73	209.00	11	200.00				
	9	73	300.00	14	348.00				
27C0Z7	10	72	1.59	14	2.10				
	11	72	1.01	5	1.00				
	12	72	2.20	10	2.10				
	1	73	1.12	20	1.00				
	2	73	0.61	14	0.60				
	3	73	4.37	17	13.00				
	4	73	3.16	1	3.40	14	2.90		
	5	73	3.08	19	2.83				
	6	73	2.56						
	7	73	2.13	8	1.30				
	8	73	3.00	11	3.00				
	9	73	3.30	14	3.83				

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/10/30

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27C001
47 28 00.0 094 39 00.0
ANDRUSIA LAKE
27 MINNESOTA

11FPALES 2111202
4 0027 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP C*MT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/07/11	18	00 0000			42							
	18	00 0004	22.4	11.4		280	8.50	147	0.080	0.080	0.015	0.008
	18	00 0015	19.3	4.0		310	7.90	170	0.040	0.050	0.023	0.008
	18	00 0020	16.7			320	7.50	170	0.040	0.050	0.020	0.007
	18	00 0027	11.2	0.6		345	7.20	178	0.040	0.110	0.026	0.007
72/09/04	18	20 0000			60	265	8.30	140	0.060	0.130	0.019	0.010
	18	20 0004	18.4	8.2		265	8.30	137	0.060	0.120	0.022	0.011
	18	20 0015	17.4	7.2		265	8.20	135	0.040	0.140	0.021	0.010
	18	20 0023	17.4	5.6		265	7.80	137	0.050	0.220	0.048	0.017
	18	20 0031	11.4	1.3		340	7.00	183	0.080	1.480	0.150	0.010
72/10/21	15	00 0000			60	242	8.30	136	0.040	0.060	0.024	0.010
	15	00 0004	6.3	11.9		242	8.20	137	0.040	0.060	0.028	0.016
	15	00 0015	6.3	11.4		240	8.20	136	0.040	0.060	0.039	0.018
	15	00 0025	6.3	11.4		242	8.20	139	0.040	0.070	0.031	0.013
	15	00 0030	6.3	10.1		242	8.20	138	0.050	0.080	0.031	0.013

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLOROPHYL 1 UG/L
72/07/11	18	00 0000	11.0J
72/09/04	18	20 0000	12.0J
72/10/21	15	00 0000	17.0J

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 74/10/31

27C0B1 L527C0B1
47 24 00.0 094 39 50.0
BIG LK/LK ANDRUSIA CONNECTION
27 CO #4, SHEET #1
T/LAKE ANDRUSIA
CO HWY 12 BRDG
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO3+NO2 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	12 00		0.063	0.710	0.060	0.005K	0.020
72/11/05	11 05		0.019	0.600	0.030	0.005K	0.017
72/12/10	10 50		0.017	1.800	0.120	0.016	0.028
73/01/20	10 30		0.015	1.150	0.280	0.005K	0.010
73/03/17	09 23		0.044	0.750	0.142	0.005K	0.010
73/04/01	14 15		0.024	1.230	0.168	0.005K	0.015
73/04/14	09 35		0.020	0.530	0.016	0.006	0.015
73/05/19	10 15		0.010K	0.710	0.013	0.007	0.020
73/06/03	10 10		0.011	0.910	0.027	0.005K	0.030
73/07/09	10 15		0.010K	0.900	0.030	0.012	0.035
73/08/11	08 50		0.017	0.540	0.030	0.008	0.035
73/09/16	10 05		0.017K	1.330	0.126	0.006	0.037

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 76/11/14

27A282 27C0A1
47 26 30.0 094 40 30.0
MISSISSIPPI RIVER
27 CO #4, SHEET #1
O/WOLF LAKE
CO HWY B BRDG .75 MI UPSTRMLK ANDRUSIA
11FPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO3&NO2 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	12 00		0.036	0.925	0.087	0.013	0.066
72/11/05	11 35		0.013	0.610	0.120	0.014	0.036
73/01/20	10 50		0.034	0.780	0.140	0.068	0.085
73/03/17	09 42		0.176	1.300	0.140	0.069	0.095
73/04/01	15 20		0.044	0.800	0.026	0.004	0.060
73/04/1[illegible]	09 50		0.012K	0.845	0.0058	0.009	0.055
73/06/07	13 00		0.014K	0.930	0.066	0.013	0.035
73/07/05			0.010K	0.935	0.013	0.012	0.045
73/09/11	09 15		0.015	1.320	0.110	0.023	0.075
73/04/14	13 20		0.015	1.200	0.115	0.060	0.145

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K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 73/1 /0

27CDCI 271501
47 26 30.0 094 38 30.0
LK ANDRUSIA/CASS LAKE CONNECTION
27 CO #4, SHEET #1
O/LAKE ANDRUSIA
CO HWY 33 BRDG 3.5 MI NW OF CASS LAKE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	[illegible] MG/L	[illegible] TOT KJEL MG/L	[illegible] TOTAL MG/L	PHOS-DIS ORTHO MG/L P	PHOS-TOT MG/L P
72/10/14	12 30		0.113	1.[illegible]	0.088	0.010	0.069
72/11/05	11 10		0.0[illegible]	0.[illegible]	0.052	0.024	0.031
72/12/1[illegible]	11 13		0.[illegible]	0.[illegible]	0.054	0.018	0.033
73/01/20	13 40		0.[illegible]	0.[illegible]	0.126	0.039	0.050
73/02/1[illegible]	12 30		0.[illegible]	0.[illegible]	0.115	0.042	0.065
73/03/17	09 37		0.[illegible]	0.[illegible]	0.074	0.034	0.055
73/04/01	14 15		0.123	0.[illegible]	0.016	0.008	0.055
73/04/1[illegible]	09 45		0.[illegible]	0.[illegible]	0.[illegible]	0.007	0.050
73/05/10	10 30		0.0[illegible]	0.[illegible]	0.005	0.005K	0.035
73/06/03	10 35		0.0[illegible]	0.[illegible]	0.009	0.005K	0.030
73/07/0[illegible]	10 30		0.[illegible]	0.[illegible]	0.012	0.007	0.030
73/08/11	13 30		0.01[illegible]	1.[illegible]	0.019	0.009	0.050
73/09/1[illegible]	10 15		0.01[illegible]	1.[illegible]	0.024	0.014	0.070

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/11/14

27A251 TF27A251 P011490
47 29 30.0 094 50 00.0
HEMIDJI
27 CO #4 SHEET #1
T/WOLF LAKE
MISSISSIPPI RIVER
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/01/23	11 00								
CP(T)-			1.250	39.900	22.000	5.400	8.400	0.785	0.984
73/01/23	13 00								
73/02/28	10 30								
CP(T)-			1.260	41.000	24.000	8.200	9.000	1.000	0.900
73/02/28	12 30								
73/03/30	10 30								
CP(T)-			2.300	26.000	11.600	9.200	9.600	0.900	0.866
73/03/30	13 00								
73/04/30	11 00								
CP(T)-			2.100	30.600	13.200	6.200	10.300	1.000	0.846
73/04/30	13 00								
73/05/31	11 30								
CP(T)-			2.820	42.000	25.100	8.890	11.500	1.350	1.000
73/05/31	13 00								
73/06/23	11 00								
CP(T)-			2.230	31.000	15.400	6.600	9.900	1.200	1.200
73/06/23	13 00								
73/07/31	11 00								
CP(T)-			2.800	26.000	7.000	3.300	9.680	1.000	1.000
73/07/31	13 00								
73/08/04	10 30								
CP(T)-			2.040	28.600	8.100			1.200	1.000
73/08/04	12 30								
73/10/01	11 00								
CP(T)-			1.050	31.500	20.000	7.000	10.500	0.925	0.900
73/10/01	13 00								
73/10/31	12 00								
CP(T)-			0.543	40.000	18.000	5.000	12.000	0.950	0.900
73/10/31	14 00								
73/11/30	11 00								
CP(T)-			0.060	44.000	28.600	4.900	11.000	0.870	0.790
73/11/30	13 00								
74/01/02	11 00								
CP(T)-			2.000	31.500	21.000	10.600	11.500	0.900	0.977
74/01/02	13 00								

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STORET RETRIEVAL DATE 74/11/14

278251 TF27A251 P011490
47 24 30.0 094 50 00.0
HEMIDJI
27 CO #4 SHEET #1
T/WOLF LAKE
MISSISSIPPI RIVER
11FPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO3&NO2 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
74/02/04	15 30								
CRITI- 74/02/04	12 00		2.320	17.500	17.600	9.600	12.500	0.950	0.932